Eastman **TETRASHIELD**™
protective resin systems

Tetrashield MP2101 protective resin system for interior can coatings

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Eastman Tetrashield™ MP2101 protective resin system is a highly durable, BPA-free resin system that enhances the performance of interior can coatings. With high solids, improved retort resistance, and broad chemical resistance, formulations featuring Tetrashield MP2101 can achieve superior performance results in interior food-contact metal packaging applications. MP2101-based formulations can be used for ends, caps and closures, and general line applications to improve coating performance as well as achieve high-solids coating formulations.

Key attributes

- Improved sterilization resistance
- Enhanced corrosion protection
- Flexibility and toughness to withstand fabrication

Typical resin physical properties

Physical form	Free-flowing, solid pellets
Glass transition temperature (DSC), °C	97
Molecular weight (Mn), g/mol (PS equivalents)	10,500
Inherent viscosity, dL/g	0.42–0.45
Acid number (mg KOH/g resin)	3
Hydroxyl number (mg KOH/g resin)	7

Single solvent solubility and Hansen solubility parameters

Solutions were prepared at 50 wt% by mixing in a steam cabinet at ~70°C for 48 hours. Solubility was determined after cooling to 25°C.

Solvent/solvent blends	Solubility
AR100	PS
AR150	S
AR150/DBE (50:50)	PS
AR150/Eastman EB solvent (50:50)	PS
AR150/Eastman PM acetate solvent (50:50)	PS
AR200	S
Benzyl alcohol	S
Eastman DB solvent	I
Eastman DB acetate solvent	I
DBE-1	PS
Eastman 2-EH acetate solvent	PS
Eastman EB acetate solvent	PS
Eastman EB solvent	I
Eastman EEH solvent	I
Eastman EEP solvent	PS
Eastman IBIB solvent	I
Eastman MAK solvent	I
Methyl ethyl ketone	PS
Eastman MPK solvent	PS
Eastman *n*-propyl propionate solvent	I
Eastman Omnia™ high-performance solvent	I
Eastman PM acetate solvent	PS
Eastman PM solvent	I
Eastman TamiSolve™ NxG dipolar aprotic solvent	S

***S** = soluble—mostly clear, **PS** = partially soluble—slight to moderate haze,*
***I** = insoluble—opaque or solid resin still present*

Hansen solubility parameters

	δ_D	δ_P	δ_H
Tetrashield MP 2101	18.81 ± 0.20	8.09 ± 0.25	5.04 ± 0.35

The Hansen solubility parameters (HSP) for Tetrashield MP2101 were determined empirically via solubility assessments in 52 solvents of different HSP attributes. It should be noted HSP are theoretical constructs for describing solvent-resin interactions and serve as guidelines for developing suitable solvent blends for a resin. Resin morphology, compatibility, and other interactions can and do ultimately influence resin solubility. Eastman offers a solvent blend calculation program that calculates the HSP of specific blends. It can be found on Eastman.com.

Co-resin compatibility

Tetrashield MP2101 is compatible with a host of polyester resins that also find utility in the can coatings industry. It should be noted that the following co-resin ratios differ due to the molecular weight differences of each resin and the desire to maintain similar hydroxyl equivalents.

	A:B ratio	Result
Tetrashield MP2100	3:1	C
Evonik DYNAPOL® L-411 polyester resin	1:1	PC
Evonik DYNAPOL® L-912 polyester resin	1:1	C
Evonik DYNAPOL® L-952 polyester resin	1:1	C
Allnex DUROFTAL® PE 6160/50MPAC	7:1	C

__C__ = compatible—clear film, __PC__ = partially compatible—slight to moderate hazy film, __I__ = incompatible—opaque film

Solids: ~45 wt% clear coating
Resin A: Tetrashield MP2101 in solution 50 wt% in Aromatic 100
Resin B: Co-resin physical form varies
Reducing solvent: 80/20 wt blend of Aromatic 100 and cyclohexanol
Crosslinker: Thermally activated polyurethane hardener
Catalyst: FASCAT® 9102 (10% solution in cyclohexanone) @ 800 ppm active tin
Cure schedule: 10 minutes @ 200°C

Cross-linker compatibility

Tetrashield MP2101 offers broad compatibility with a variety of cross-linker types commonly used in the can coatings industry, such as thermally activated polyurethane hardeners, melamine resins, and benzoguanamines to achieve the desired performance properties of the finished coating.

Cross-linker compatibility data

Cross-linker	Type	Compatibility
Desmodur® VP LS2078	Thermally activated polyurethane hardener	C
Maprenal® BF 892/68B	Benzoguanamine	C
CYMEL® 1123	Methylated/ethylated benzoguanamine	C
CYMEL® 303 LF	Highly-methylated melamine	C
Curaphen® 40-856-B60	m-Cresol phenol	C
Curaphen® 40-872-B80	Etherified cresol-based resole	I
Curaphen® 40-875-B55	Etherified cresol-based resole	I
PHENODUR® PR 285	Phenol	C

__C__ = compatible—clear film, __PC__ = partially compatible—slight to moderate hazy film, __I__ = incompatible—opaque film

Catalyst selection

Catalyst selection is dependent on the cross-linker type. FASCAT® 9102 provides an acceptable cure response when catalyzing the reaction of Tetrashield MP2101 with thermally activated polyurethane hardeners targeted for direct food contact applications. Other catalysts for food contact applications include FASCAT® 2003 and FASCAT® 9100. K-KAT® XK-672 provides adequate cure for those desiring a catalyst that is not tin-based. With melamine and benzoguanamine chemistries, Tetrashield MP2101 responds well to phosphoric acid and strong acid catalysts such as dodecylbenzenesulfonic acid (DDBSA). *p*-Toluenesulfonic acid (PTSA) can be used for exterior can coating applications but does not meet FDA criteria for internal can coatings. Phosphoric acid catalysts are also used with phenolic cross-linkers, providing adequate cure with Tetrashield MP2101. Catalyst blends can exhibit synergistic effects in some formulations.

Pigmentation

Tetrashield MP2101 can be pigmented with titanium dioxide using traditional dispersion techniques and exhibits good compatibility with a variety of types and surface treatments. Pigment levels of 20–30 wt% based on total formulation solids typically provide sufficient hiding for most applications. Pigmentation level and type can affect the final film properties, so a ladder study is recommended for optimization.

Additives

Several potential additives for formulating Tetrashield MP2101 in solventborne systems are listed in the following table. Additives in bold are used in the starting point formulations included in this brochure. Additives not in bold are typically used in food contact-approved formulations. Other manufacturers offer similar products that may also work with Tetrashield MP2101.

Additive	Function
BYK-P 104	Pigment stabilizer (inorganic and organic)
BYK-054, BYK-057, **BYK-088**	Defoamer
BYK-350, BYK-359	Flow/leveling
BYK-4510	Adhesion
BYK-313	Wetting
LUBA-print 501, LUBA-print 436, LUBA-print 897	Slip additive

The solubility and compatibility data in this brochure is intended to provide guidance when formulating with Tetrashield MP2101. The listings are not exhaustive, as many other raw materials are available for metal packaging coating systems. The solubility and compatibility of these materials should be tested for suitability in specific formulations. Samples of Tetrashield MP2101 are available for this purpose. You may request samples online at **Eastman.com/Tetrashield** or contact your Eastman representative in your region.

Starting point formulations

Several starting point formulations have been developed to highlight the performance of MP2101 utilizing various raw materials. The formulations are effective across a variety of metal substrates commonly used in metal food packaging applications.

While curing conditions for the formulations are dependent on the equipment used, typically these formulations target a peak metal temperature of 200°C for 10 minutes. The target cured film weight can range from 6 –18 gsm, depending on the formulation, and should be adjusted to meet final performance requirements. Wet film application was carried out using a wire-wound bar applicator suitable to provide the needed film weight. Viscosity adjustments may be needed in some instances, depending on the application method.

Formulation 1: Co-resin blend—white polyurethane

Component	Wt%
Tetrashield MP2100 (55 wt% in A100)	11.38
Tetrashield MP2101(45 wt% in A100)	4.88
Pigment grind (1:1 polyester/Ti-Pure™ R-900)[a]	58.78
Desmodur® BL 2078 (60% in A100)	9.80
FASCAT® 9102 (10% in A100)	0.87
Aromatic 100 solvent	12.32
LUBA-print 501 wax additive (10%)	1.87
BYK-088 defoamer	0.10
Total	***100.00***

[a]Pigment grind prepared using a MP2100/MP2101 70:30 weight ratio blend of the corresponding resin solutions in A100. Pigment added under low shear using a Cowles disperser. After adding the pigment, the speed of the Cowles blade was increased to produce the desired 7+ Hegman fineness of grind rating per ISO 1524.

Formulation 1 solution properties	Typical value
% Nonvolatiles, weight	60.1
% Nonvolatiles, volume	41.5
Viscosity, ISO 6, seconds @ 23°C	96–98
Pigment-to-binder weight ratio	1:1
Polyurethane/binder	20/80
% Catalyst on binder	0.30
VOC, g/L	509
Density, kg/L	1.27

Formulation 1 film properties	Test	Typical value
Cured film weight	g/m^2	7–8
Wedge bend	mm failure, 10-cm width	23
Retort resistance, 3% HAc	Roughness rating 0–5 (5 = best) (vapor/liquid phase)	4.5/3.5
Solvent resistance	MEK double rub, 0.5 kg	100+

Formulation 1 highlights the performance of Tetrashield MP2101 as a co-resin in combination with Tetrashield MP2100 utilizing a thermally activated polyurethane cross-linker. The high molecular weight and linear characteristics of Tetrashield MP2101 offer desirable properties such as flexibility and toughness to meet the demanding performance needs in metal food packaging.

Formulation 2: Co-resin blend—gold-phenolic modified polyurethane formulation

Component	Wt%
Tetrashield MP2100 (55 wt% in A100)	37.71
Tetrashield MP2101(45 wt% in A100)	19.76
Curaphen 40-856-B60 (60% in *n*-butanol)	6.58
Desmodur® BL 2078 (60% in A100)	9.88
FASCAT® 9102 (10% in A100)	1.18
Aromatic 100 solvent	21.89
LUBA-print 436 wax additive	2.00
LUBA-print 897/PM (ND) wax additive	1.00
Total	***100.00***

Formulation 2 solution properties	Typical value
% Nonvolatiles, weight	41.1
% Nonvolatiles, volume	33.3
Viscosity, ISO 6, seconds @ 25°C	50–80
% Polyurethane on binder	15.0
% Phenolic on binder	10.0
% Tin catalyst on binder	0.30
% Waxes on binder	1.0
VOC, g/L	578
Density, kg/L	0.981

Formulation 2 film properties	Test	Typical value
Cured film weight	g/cm^2	6–7
Wedge bend	mm failure, 10-cm width	8
Retort resistance, 3% HAc	Roughness rating 0–5 (5 = best) (vapor/liquid phase)	4/4.5
Solvent resistance	MEK double rub, 0.5 kg	29

Formulation 2 is a gold-phenolic modified polyurethane hybrid, again utilizing a blend of Tetrashield MP2100 and Tetrashield MP2101. Co-resin/co-cross-linker formulations such as this are becoming more common in the metal packaging industry as a means of improving overall performance.

Formulation 3: Tetrashield MP2101 polyester–gold-phenolic organosol hybrid

Organosols have been used in the metal food packaging industry for years for challenging food packs. Formulation 3 depicts a starting point formulation using Tetrashield MP2101 in combination with a phenolic cross-linker and a food contact-approved PVC dispersion particularly suited for metal food packaging. Preparing the formulation involves two steps: preparing the initial PVC/polyester base and subsequent letdown into the final formulation.

Organosol—polyester premix solution	Wt%
1. Tetrashield MP2101(45 wt% in A100)	18.34
2. Aromatic 100 solvent	10.00
3. Benzyl alcohol	5.00
4. Eastman 168™ non-phthalate plasticizer	4.00
5. VESTOLIT G 178 PVC powder	45.00
6. Aromatic 100	10.66
7. Benzyl alcohol	7.00
Total	***100.00***

1. Combine the first four components under low shear (~500 RPM) using a Cowles disperser blade.
2. To ensure full wetting, add the VESTOLIT G 178 PVC powder slowly at the same RPM.
3. After PVC addition, increase RPM to 2500 and process until mixture temperature reaches 40°C.
4. Add the remaining Aromatic 100 and benzyl alcohol to cool the premix below 33°C.
5. Hegman grind gauge should be > 7.

Formulation 3 components	Wt%
Tetrashield MP2101 organosol premix	55.66
Tetrashield MP2101(45 wt% in A100)	25.15
Curaphen 40-856-B60 phenolic resin	10.31
LUBA-print 897/PM (ND) wax	3.09
Aromatic 100 solvent	3.61
Benzyl alcohol	1.55
FASCAT® 9102 (10% in Aromatic 100 solvent)	0.41
NACURE® XC296	0.12
Dynoadd®-F300 additive solution	0.10
Total	***100.00***

Combine components under low shear (~500 RPM) using a Cowles disperser blade.

Formulation 3 solution properties	Typical value
% Nonvolatiles, weight	50.3
% Nonvolatiles, volume	38.9
Viscosity, ISO 6, seconds @ 23°C	45–100
% Polyester on binder	31.6
% Phenolic on binder	12.3
% PVC on binder	49.8
% Waxes on binder	0.9
% Plasticizer on binder	4.0
VOC, g/L	520
Density, kg/L	8.736

Formulation 3 film properties	Test	Typical value
Cured film weight	g/cm^2	10–18
Wedge bend	mm failure, 10-cm width	5
Retort resistance, 3% HAc	Roughness rating 0–5 (5 = best) (vapor/liquid phase)	4/3

Tetrashield MP2101 improves the performance and durability of interior and exterior food packaging coatings while reducing environmental impact and optimizing coating processes. Tetrashield MP2101 has shown in laboratory tests to offer a unique combination of flexibility, chemical resistance, and corrosion resistance, enabling superior protection of food, beverages, and consumer products in a BPA-free formulation.

A good can preserves more than food. It preserves trust. Tetrashield protects the food and beverage cans that consumers trust and brands are proud to put their names on.

For more information, visit **Eastman.com/Tetrashield**.

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